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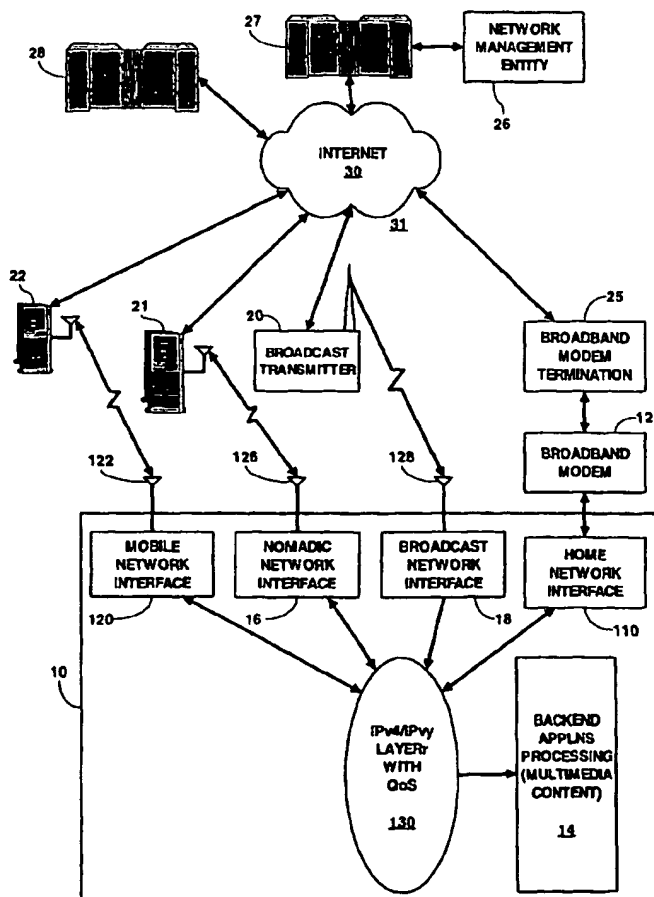
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(54) Title: A MULTI-NETWORK MOBILE COMMUNICATION SYSTEM



(57) Abstract: A communication system for communicating via the Internet, includes a portable communications device, and a plurality of networks interconnecting, at least occasionally, the internet with the portable communications device. An intelligent content server is also interconnected to the Internet. A network management entity, is interconnected to the intelligent content server, and chooses which network is to be used for communicating between the intelligent content server and the portable communications device.

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1 **SEAMLESS COMMUNICATIONS THROUGH OPTIMAL NETWORKS**

2 Field of the Invention

3 The present invention relates generally to mobile
4 communications platforms and more specifically to
5 communications optimization using an intelligent network
6 selection.

7 Background of the Invention

8 Mobile or cellular telephone devices are configured
9 to communicate with a plurality of antennas, either
10 ground or satellite based, which are ultimately connected
11 to the traditional telephone system. Regardless of the
12 specific path used there is a direct link between the
13 cellular telephone and the telephone system communication
14 network. Digital cellular telephone devices are further
15 capable of transmitting to and receiving digital data
16 from a digital data network, such as the Internet, with
17 which the telephone system is interconnected. Such
18 devices have been termed personal communications systems
19 (PCS) devices. Such enhanced PCS devices can request,
20 receive and display information from the internet such as
21 maps, e-mail, text, web pages, audio and video files.

22 One problem associated with such enhanced
23 capabilities is the bandwidth required to transmit such
24 large volumes of data. Problems with scheduling and
25 routing of data transmissions, as well as inefficient
26 allocation of data transmission capacity, are present in
27 many existing data communications networks. For example,
28 the global interconnection of computer networks known as

29 the Internet routes data packets with the anticipation
30 that the packets will eventually be delivered to the
31 intended receiver but it is not uncommon for packets to
32 be lost or delayed during transmission. Further, the
33 internet does not differentiate between different types
34 of data being transmitted.

35 Data packets requiring delivery within a certain
36 time frame such as real time audio or video
37 communications receive no preference in transmission
38 over packets that generally do not require a particular
39 time of delivery, such as electronic mail. Data packets
40 carrying important information in which packet loss
41 cannot be tolerated, such as medical images, receive no
42 greater priority than other data packets. Because all
43 data packets are viewed as equally important in terms of
44 allocating transmission resources, less critical
45 transmissions such as e-mail may serve to delay or
46 displace more important and time sensitive data.

47 Capacity for data transmission in existing data
48 communications networks is often inefficiently allocated.
49 In some instances transmission capacity or bandwidth is
50 allocated to a particular user according to a fixed
51 schedule or particular network architecture, but the
52 available bandwidth is not actually used. In other
53 instances, a user is precluded from transmitting a burst
54 of data that, for the moment, exceeds the user's
55 bandwidth allocation. Existing data communications
56 networks often lack mechanisms whereby bandwidth may be
57 allocated on demand.

58 The current cellular telephone system uses
59 relatively low bandwidth signaling techniques on the
60 order of fifty kilobits per second. Graphical
61 information such as maps and pictures require relatively
62 wide bandwidths in order to achieve reasonable response
63 times. Video and audio files require even higher
64 bandwidths for adequate response times. With limited
65 spectrum resources, the cost of bandwidth on a relatively
66 narrow band network can be high.

67 Current television signal broadcasting systems
68 provide relatively wide bandwidth capability on the order
69 of twenty megabits per second for each six megahertz
70 wide television channel. Terrestrial frequency bands in
71 the United States include almost four hundred megahertz
72 of available spectrum. Terrestrial broadcast channels
73 typically have a reception radius of approximately
74 seventy miles, dependent largely on local terrain.

75 Direct digital satellite television broadcasting
76 systems can also provide digital channels which can be
77 used for digital information transmission. An example of
78 such a system is disclosed in United States Patent No.
79 6,366,761, entitled PRIORITY BASED BANDWIDTH ALLOCATION
80 AND BANDWIDTH ON DEMAND IN A LOW EARTH ORBIT SATELLITE
81 DATA COMMUNICATIONS NETWORK, issued on April 2, 2002 to
82 Montpetit. Digital data from these channels are
83 receivable over a much wider area typically including
84 tens of thousands of square miles. These channels are
85 not completely used. Thus there is a vast amount of
86 unused television broadcast spectrum available for other
87 uses.

88 Some data which will be requested by a user of a PCS
89 device will be unique to that user, such as an e-mail
90 addressed only to that user. Other data will be of
91 simultaneous interest to a large number of users, such
92 as weather data or stock market quotations. Other
93 information will be of widespread simultaneous interest
94 only at certain times, such as IRS tax forms during the
95 second week of April. The Internet and the associated IP
96 protocols will be expected to enable the increasing
97 demand for data. Network connectivity can be established
98 through a variety of means including connecting to a
99 broadband modem (cable, DSL or satellite) through wired
100 or wireless means, or by connecting to a nomadic network
101 such as offered by wireless LAN standards, or by
102 connecting to a mobile network. Current bandwidth for
103 cellular telephone devices is barely sufficient to
104 provide unique information to a particular PCS device as
105 such information is requested, and more efficient methods
106 of accessing the appropriate network for the bandwidth
107 actually needed must be found if all of the available
108 bandwidth is not to become exhausted by the increasing
109 number of users.

110 Within a single network the mechanism or protocol
111 needed to connect to that network in order to obtain a
112 range of services is a straightforward problem with known
113 solutions. However, when one must traverse between
114 different networks the problem of making a seamless
115 transition is substantial. For example, in second
116 generation cellular networks it is often possible to
117 connect to a different network on a per session basis.

118 Unfortunately, the possibility of optimizing
119 bandwidth at the packet level is not available because
120 the mechanism for communicating across networks has no
121 common protocol layer. In the Internet, the commonly
122 used protocol is termed IPv4 which has a set of tools
123 that enables mobility management. These set of protocols
124 are termed Mobile IP protocols. Several enhancements
125 to the IPv4 protocols have resulted in a second
126 generation termed IPv6. In addition to an expanded
127 address space of 128 bits instead of the 32 bits used by
128 IPv4, there are several features that enable better
129 mobility management. Mobility can be managed by using
130 the static IP addressing schemes in IPv6. In IPv4, due
131 to the scarcity of address space, dynamic and local IP
132 address assignment is often used. The efficiency of
133 address management is expected to be better in IPv6 which
134 will result in better service overall. An example of a
135 mobile system using IPv6 is disclosed in United States
136 Patent No. 6,172,986, entitled MOBILE NODE, MOBILE AGENT
137 AND NETWORK SYSTEM, issued to Watanuki et al. on January
138 9, 2001.

139 Data requested by the user may be of a time critical
140 nature and need to be delivered with strict time
141 constraints. Alternatively, data may also be downloaded
142 with less severe time constraints. The former calls for
143 Quality of Service (QoS) constraints that need to be
144 supported by the network. The latter is the typical
145 download model for Internet content and is termed a best-
146 effort delivery. Finally, data may also be delivered
147 with a time delay. Examples could include music or
148 multimedia which the user wishes to view at a later time.

149 This category represents the most flexibility afforded
150 from a network optimization and usage viewpoint.

151 Given the existence of the many networks, bandwidths
152 and accessibility variables briefly alluded to in the
153 foregoing, a need exists for a mechanism that allows the
154 user to seamlessly roam or transition between these
155 networks, based on a calculation of the needed bandwidth,
156 message priority, and bandwidth cost, such that the
157 minimum required bandwidth at the lowest cost is always
158 selected.

159 Summary of the Invention

160 In accordance with the principles of the present
161 invention, a communication system for communicating via
162 the Internet, includes a portable communications device,
163 and a plurality of networks interconnecting, at least
164 occasionally, the internet with the portable
165 communications device. An intelligent content server is
166 also interconnected to the Internet. A network
167 management entity, is interconnected to the intelligent
168 content server, and chooses which network is to be used
169 for communicating between the intelligent content server
170 and the portable communications device.

171 In such a communications system, the problem of
172 optimizing network selection by choosing the most cost
173 effective available bandwidth is addressed by
174 implementing the portable communications device as a
175 portable intelligent multiple network platform. The
176 platform includes multiple front end interfaces, with
177 each interface corresponding to a type of available

178 network, such as a home network interface, broadcast
179 network interface, nomadic network interface and a mobile
180 network interface. The home network interface is
181 typically plugged into a broadband modem, while the other
182 interfaces utilize an antenna terminal to perform
183 wireless communications.

184 Within the platform each network interface is
185 interconnected to a network data processing layer capable
186 of transmitting and receiving data via either the IPv4 or
187 IPv6 protocol. For large files requiring substantial
188 bandwidths, such as multimedia applications, the network
189 data processing layer is interconnected to a discrete
190 backend applications processor which processes and
191 buffers the data stream.

192 Each network interface transmits to and receives
193 data from a base station or network termination dedicated
194 to that particular type of network. In turn, each such
195 base station or termination has an appropriate connection
196 to the Internet. Also connected to the Internet is an
197 intelligent content server which is interconnected to a
198 network management entity. In order for the intelligent
199 content server to communicate with the portable
200 intelligent multiple network platform, the platform
201 registers into any of the available networks through any
202 physical layer having a return channel.

203 The platform can function with the existing mobile
204 IPv4 protocols or can use the static IPv6 global
205 addressing scheme. The platform communicates with the
206 intelligent content server and informs the server of its
207 current IP address and its current specific multi-

208 networking capabilities. The intelligent network
209 management entity chooses the appropriate network to use
210 for each packet which is to be transmitted or received
211 based on optimizing criteria such as priority, desired
212 transmission quality, required bandwidth and cost.

213 When the portable platform leaves the current
214 network within which it is operating (typically due to
215 physically travelling beyond the range of the current
216 network), the portable platform automatically searches
217 for and tries to connect to the next best (based on the
218 optimization criteria) network. When a new connection is
219 successfully accomplished, the portable platform sends
220 information to the network management entity regarding
221 its current connection. In response to this information,
222 the intelligent network management entity routes
223 subsequent packets through the newer optimum network
224 route. This process can be managed at either a per-
225 packet or per-session level.

226 Brief Description of the Drawings

227 Figure 1 is a block diagram illustrating portable
228 communications network selection optimizing system
229 according to the principles of the present invention; and

230 Figure 2 is a block diagram of a personal
231 communications system device according to the principles
232 of the present invention, which may be used in the system
233 as illustrated in Figure 1.

234 Detailed Description of the Invention

235 Figure 1 is a block diagram of a mobile
236 communications system including a multiple network
237 portable platform 10 which is capable of bidirectional
238 transmission and reception with either a broadband modem
239 12 or with any of a plurality of wireless communications
240 networks via antennas 122, 126 and 128. In practice the
241 antennas 122, 126 and 128 may be a single physical
242 antenna with appropriate matching networks or it may be
243 one or more antennas in close physical proximity. The
244 antenna 122, for example, is responsive to digital
245 cellular telephone signals from, for instance, a cellular
246 telephone mobile network termination or base station 22.
247 The antenna 122 is bidirectionally coupled to a mobile
248 interface circuit 120.

249 As also seen in Figure 2, the mobile interface
250 circuit 120 is coupled to a direct data input terminal of
251 a microprocessor 118. A direct data output terminal of
252 the microprocessor (μ P) 118 is coupled to an input
253 terminal of the mobile interface 120. An audio output
254 terminal of the microprocessor 118 is coupled to an input
255 terminal of the speaker 114. An output terminal of a
256 microphone 112 is coupled to an audio input terminal of
257 the microprocessor 118. An output terminal of a keypad
258 116 is coupled to a control input terminal of the
259 microprocessor 118.

260 The microprocessor operates in a known manner under
261 the control of an application program stored in memory
262 such as a Read Only Memory (ROM) in the microprocessor

263 118. In particular, the microprocessor is programmed to
264 operate as a data processing layer 130 utilizing the both
265 the current Internet Protocol version 4 (IPv4) and the
266 still developing next generation Internet Protocol
267 version 6 (IPv6). The layer 130 may include a Quality of
268 Service (QoS) program as is well known to those of
269 ordinary skill in this field.

270 The microprocessor 118 also includes a backend
271 applications processor 14 which is capable of
272 bidirectional communication with the Internet Protocol
273 layer 130. The processor 14 serves as a buffer and
274 decoder for data received by microprocessor 118, and is
275 particularly useful for processing data having a
276 multimedia content such as audio and video files. The
277 backend processor 14 may also be a discrete circuit or
278 combination of integrated circuits that are external to
279 the microprocessor 118 but which are still mounted on the
280 multiple network portable platform 10.

281 The platform 10, as described above, operates in a
282 known manner to allow a user to make telephone calls.
283 The user manipulates the keys on the keypad 116 to
284 instruct the microprocessor 118 to cause the mobile
285 interface circuit 120 to connect to an external network,
286 such as the Internet 30, or a mobile telephone
287 communications network via the mobile base station 22.
288 The keypad 116 generates dialing tones specifying the
289 desired telephone number or instructional code.
290 Alternatively, signals may be received from the Internet
291 30 or from the cellular telephone network indicating that
292 someone is attempting to call the portable platform 10.

293 In response to these signals, the microprocessor 118
294 conditions the mobile interface circuit 120 to connect to
295 the network and complete the call.

296 In either event, signals representing spoken
297 information from the microphone 112 are digitized by the
298 microprocessor 118, and the digitized signal is
299 transmitted through the mobile interface 120 and the
300 antenna 122 to the mobile network base station 22.
301 Simultaneously, signals received by the antenna 122 from
302 the base station 22, and representing received digitized
303 speech information from the other party, are received by
304 the mobile interface 120, converted to a sound signal by
305 the microprocessor 118 and supplied to the speaker 114.

306 As described above, the multiple network platform 10
307 also provides the capability of requesting and receiving
308 information from a computer, typically via the internet.
309 Data representing requested information may be generated
310 by the user from the keypad 116, which may have more keys
311 than illustrated in Figure 2. The information request
312 is supplied by the microprocessor 118 to any of the
313 network interfaces available on the network platform 10.
314 For example, the platform 10 may include not only a
315 mobile interface 120, but also a home network interface
316 110, a nomadic network interface 16, and a broadcast
317 network interface 18. Depending on which network is
318 available for use, the information request is transferred
319 to either a broadband modem 12 or one of the antennas
320 122, 126 or 128.

321 Regardless of the network in use at a particular
322 time, the information request is transmitted to the

323 Internet 30. Also supplied by the common layer 130 is a
324 status report regarding which of the network interfaces
325 16, 18, 110 and 120 is currently in communication with
326 its associated network. Each of these networks will have
327 unique characteristics associated with its particular
328 network path. These characteristics will include the
329 bandwidth of the network path, the monetary cost of using
330 the network, the data transmission speed available, the
331 quality and reliability of the network, the geographic
332 coverage of the network and the type of data best suited
333 for transmission via the particular network path. By
334 transmitting the current universe of network
335 availability, a recipient may be able to select the most
336 appropriate network for transmission of return data.

337 The information transmitted by platform 10 to the
338 Internet 30 will be received by a server machine such as
339 intelligent content server 27 which contains the
340 information desired by the user of the portable platform
341 10. Interconnected to the content server 27 is a network
342 management entity 26 which receives the network
343 availability or status report from platform 10. The
344 management entity 26 is programmed to optimize the
345 selection of the network via which its associated content
346 server 27 will transmit and receive data to and from the
347 platform 10.

348 There exist two possible modes of transmitting the
349 desired information from the server 27. The first mode
350 is a *unicast mode* in which the server's data is intended
351 only for a specific user's platform 10. The second
352 possible mode is a *multicast mode* in which the server's

353 data is intended for simultaneous transmission to a
 354 plurality of platforms 10.

355 In either case the objective of the server 27 is to
 356 transport P packets to the platform 10 by routing the
 357 data through the backbone or internal structure of the
 358 internet 30 to the "edge" 31 of its global computer
 359 network, and to continue the data transmission from the
 360 edge 31 across the chosen communications access network
 361 20, 21, 22 and/or 25 to the platform 10.

362 In order for the network management entity 26 to
 363 optimize its choice of a particular network from the
 364 universe of available networks, the goal for the unicast
 365 mode is to minimize the expression:

$$366 \quad \text{Minimize} \left[P_j \sum_i ((x_i + y_i) N_i) \right] \text{ subject to } \sum_j P_j = P$$

367 where

368 x_i is the cost of transporting each data packet
 369 through the internet 30 to its edge 31 for the i th access
 370 line;

371 y_i is the cost of transporting each packet through
 372 the respective access networks, e.g. 20, 21, 22, 25;

373 P_j is the number of packets transported on link i ;

374 and

375 N_i is the number of users on the i th link requesting
 376 the content of server 27.

377 The unicast expression can be solved as an
 378 optimization problem using standard optimization
 379 techniques, which will result in reducing the cost of

380 transporting each packet through the entire network, that
381 is, through the internet 30 and through the following
382 communications network 20, 21, 22 or 25. To enable
383 quality of service, the cost structure for each segment,
384 x_i and y_i used earlier are appropriately reflected and
385 the optimization problem is solved with the new numbers.

386 For the multicast case, the goal is to minimize the
387 following expression:

388
$$\text{Minimize} \left[P_j \sum_i (x_i + y_i) \right] \text{ subject to } \sum_j P_j = P$$

389 This expression is identical to the unicast mode
390 except that the penalty incurred for multiple users
391 requesting server content (N_i) is removed. This
392 expression also can be optimized using well known
393 optimization techniques. Each optimization may be
394 performed on either a per packet or per session basis.

395

1

CLAIMS

2 1. A communication system for communicating via the
3 Internet, comprising:
4 a portable communications device;
5 a plurality of networks, each network inter-
6 connecting, at least occasionally, the internet with the
7 portable communications device;
8 an intelligent content server, the content server
9 being interconnected to the Internet; and
10 a network management entity, the network management
11 entity being interconnected to the intelligent content
12 server, the network management entity choosing which
13 network is to be used for communicating between the
14 intelligent content server and the portable
15 communications device.

1

1 2 The communications system of claim 1, wherein the
2 portable communications device comprises a plurality of
3 network interfaces for establishing a communications link
4 with each of the plurality of networks, respectively.

1

1 3. The communications system of claim 2, wherein the
2 portable communications device further comprises a
3 microprocessor programmed to process data via any of the
4 network interfaces.

1

1 4. The communications system of claim 3, wherein the
2 network management entity is programmed to choose the
3 network to be used for communicating with the portable
4 device based on available bandwidth of each of the
5 plurality of networks.

1

1 5. The communications system of claim 4, wherein the
2 network management entity evaluates a cost associated
3 with each network when choosing the network to be used
4 for communicating with the portable communications
5 device.

1

1 6. The communications system of claim 5, wherein the
2 network management entity evaluates a quality-of-
3 transmission value associated with each network when
4 choosing the network to be used for communicating with
5 the portable communications device.

1

1 7. The communications system of claim 6, wherein the
2 network management entity evaluates the network to be
3 used for communicating with the portable communications
4 device for each data packet to be transmitted between the
5 intelligent content server and the portable
6 communications device.

1

1 8. The communications system of claim 6, wherein the
2 network management entity evaluates the network to be

3 used for communicating with the portable communications
4 device for each data transmission session.

1

1 9. The communications system of claim 8, wherein the
2 microprocessor is programmed to transmit all information
3 to and from each network interface by using a common
4 Internet protocol layer.

1

1 10. The communications system of claim 9, wherein the
2 microprocessor is programmed:
3 to determine which of the plurality of networks is
4 operational;
5 to transmit information representing which of the
6 plurality of networks is operational to the network
7 management entity.

1

1 11. A data transmission optimization system for use in
2 multi-network environments, comprising:
3 an intelligent content source (27);
4 an intelligent network management entity (26)
5 interconnected to the intelligent content source;
6 a multi-network platform (10) interconnected to a
7 plurality of communications networks, the multi-network
8 platform transmitting a communications network status
9 report to the intelligent management entity, the
10 intelligent management entity selecting a communications
11 network (20, 21, 22, 25) for transmission of data from

12 the intelligent content source to the multi-network
13 platform.

1

1 12. The data transmission optimization system of claim
2 11 wherein the intelligent management entity selects one
3 of the communications networks based on an optimization
4 algorithm that includes network bandwidth as a variable.

1

1 13. The data transmission optimization system of claim
2 11 wherein the optimization algorithm evaluates network
3 cost of data transmission as a variable.

1

1 14. The data transmission optimization system of claim
2 11 wherein the optimization algorithm evaluates network
3 quality of data transmission as a variable.

1

1 15. The data transmission optimization system of claim
2 11 wherein the intelligent management entity selects one
3 the communications networks for each data transmission
4 session with the multi-network platform.

1

1 16. The data transmission optimization system of claim
2 11 wherein the intelligent management entity selects one
3 of the communications networks for each data packet
4 transmitted to the multi-network platform.

1 17. A method of optimizing data transmission between a
2 portable platform and an intelligent content server by
3 optimizing a communications network selection in a multi-
4 network environment, comprising the steps of:
5 determining which communications networks are
6 connected to the portable platform;
7 transmitting a communications network status report
8 to the intelligent content server;
9 causing a network management entity to evaluate
10 characteristics of the communications networks connected
11 to the portable platform; and
12 causing the network management entity to select a
13 communications network based on the evaluated
14 characteristics; and
15 transmitting data from the intelligent content
16 server to the portable platform via the selected
17 communications network.

1

1 18. The method of claim 17, further comprising the step
2 of evaluating characteristics of the communications
3 networks for each data transmission session.

1

1 19. The method of claim 17, further comprising the step
2 of evaluating characteristics of the communications
3 networks for each data packet to be transmitted.

1

1 20. The method of claim 17, wherein data is transmitted
2 from the intelligent content server to the portable
3 platform via a common internet protocol layer

1

1

1/2

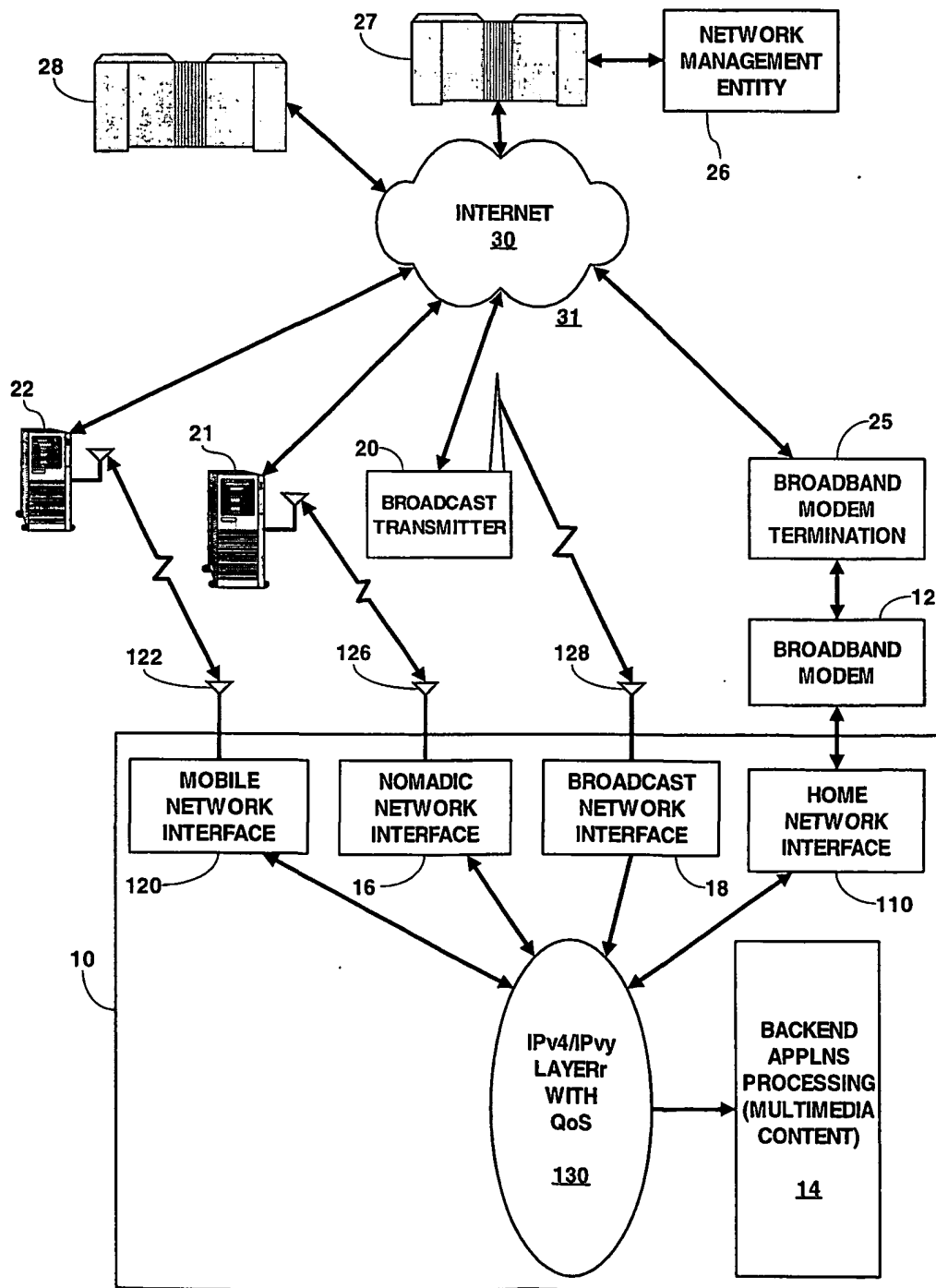


Fig. 1 – System

2/2

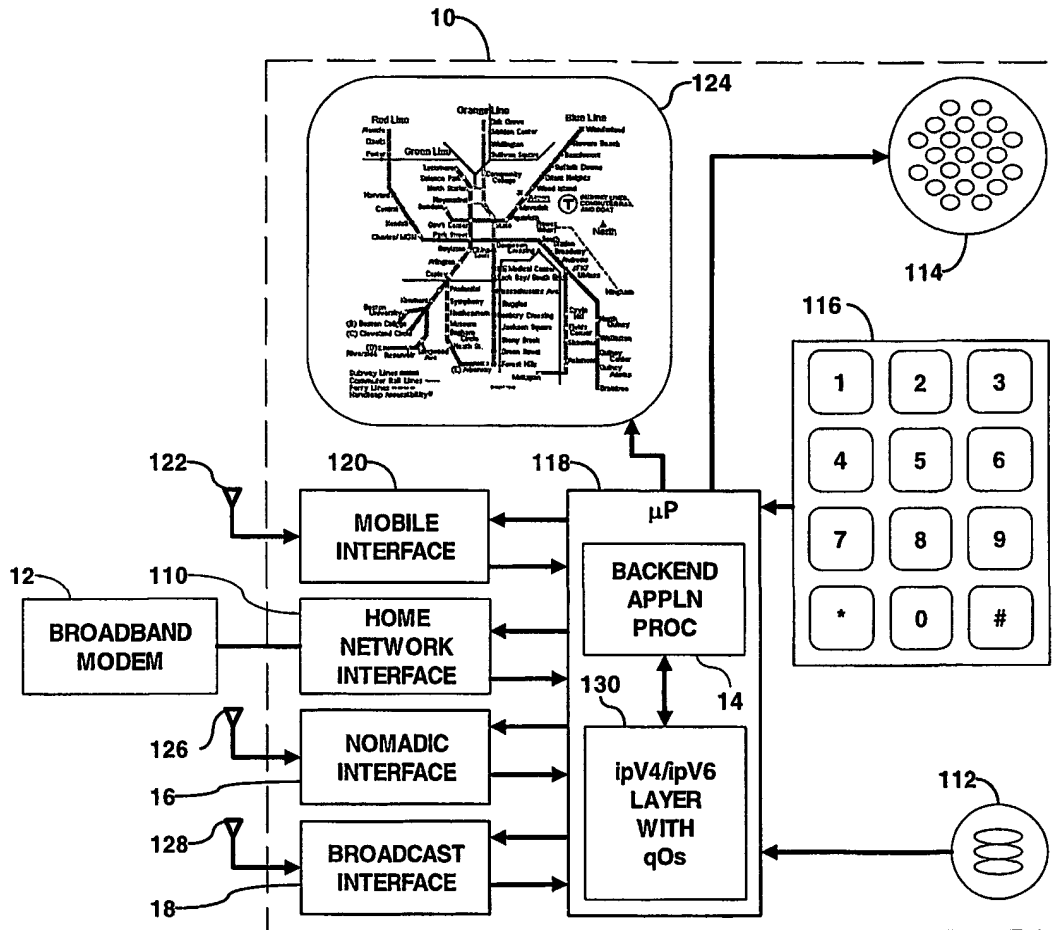


Fig. 2 - Terminal